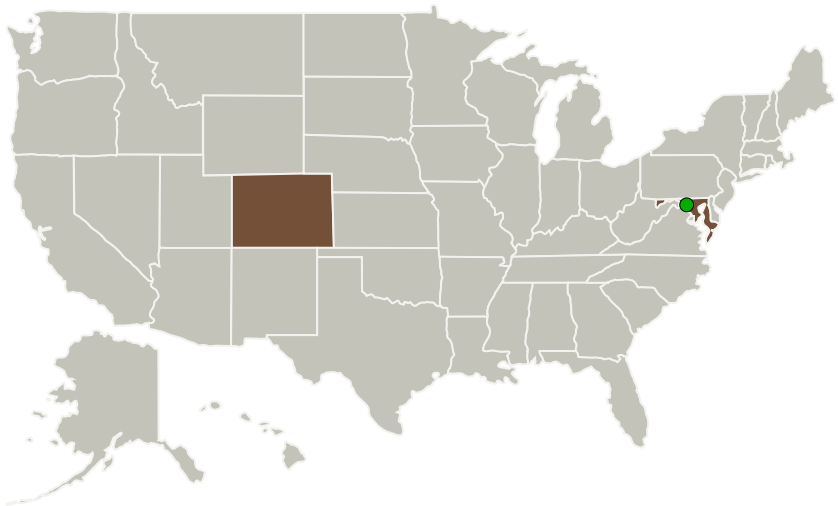
Continuation Methods and Non-Linear/Non-Gaussian Estimation for Flight Dynamics, Phase I

Completed Technology Project (2010 - 2010)

Project Introduction

We propose herein to augment current NASA spaceflight dynamics programs with algorithms and software from two domains. First, we propose to use numerical parameter continuation methods to assist in computation of trajectories in complicated dynamical situations. Numerical parameter continuation methods have been used extensively to compute a menagerie of structures in dynamical systems including fixed points, periodic orbits, simple bifurcations (where the structure of the dynamics changes), Hopf bifurcations (where periodic orbits are created), invariant manifolds, hetero/homoclinic connections between invariant manifolds, etc. Perhaps more importantly for the current work, such methods have already proven their worth in flight dynamics problems, especially those having to do with the complicated dynamics near libration points. Second, we propose to use advanced filtering techniques and representations of probability density functions to appropriately compute and manage the uncertainty in the trajectories. While advanced methods for understanding and leveraging the underlying dynamics are clearly necessary for effective mission design, planning, and analysis, we contend that they do not suffice. In particular, they do not, in and of themselves, address the issue of uncertainty. Herein we discuss methods that balance the accuracy of the uncertainty representation against computational tractability, including a discussion of the notorious ``curse of dimensionality'' for problems with large state vectors. We propose approachs that revolve around modifications of algorithms such as ``log homotopy'' particle filters and especially Gaussian sum filters. Finally, we propose to integrate all of the above algorithms into standard NASA software packages GEONS, GIPSY, and GMAT.

Primary U.S. Work Locations and Key Partners



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Organizations Performing Work	Role	Type	Location
Numerica Corporation	Lead Organization	Industry	Fort Collins, Colorado
Goddard Space Flight Center(GSFC)	Supporting Organization	NASA Center	Greenbelt, Maryland

Primary U.S. Work Locations	
Colorado	Maryland

Project Transitions

January 2010: Project Start

July 2010: Closed out

Closeout Documentation:

- Final Summary Chart*(https://techport.nasa.gov/file/139979)*

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Numerica Corporation

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

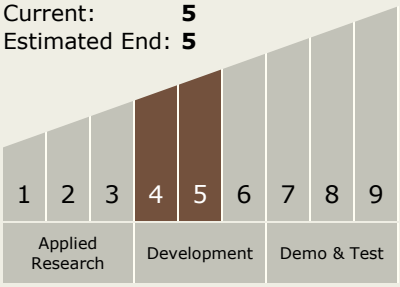
Carlos Torrez

Principal Investigator:

Randy Paffenroth

Technology Maturity (TRL)

Start: **4**
Current: **5**
Estimated End: **5**



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Technology Areas

Primary:

- TX17 Guidance, Navigation, and Control (GN&C)
  - TX17.2 Navigation Technologies
    - TX17.2.3 Navigation Sensors

Target Destinations

The Sun, Earth, The Moon, Mars, Others Inside the Solar System, Outside the Solar System